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FORCED CONVECTION UPON HEAT SINK OF AL-Cu FOR DESIGN OPTIMIZATION BY EXPERIMENTAL AND CFD ANALYSIS FOR COOLING IN CPU

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ABSTRACT

A heat sink device, for use with specific power input at 100V and 20W to the heater, attached at the base plate of copper, and then obtained the average temperature of Heat sink with the help of 12 thermocouples. Two specimens of heat sinks were designed and were tested for mass flow rate and heat transfer coefficient with base of 1mm&2mm&tip dimensions varying as 0.5mm, 1.00mm, respectively. By experimenting and CFD simulations, optimization of heat sink design was done. Then, correlation and validation were to be adopted.

KEYWORDS: Base Plate, Cooling Fan, CFD Simulation, Heat Sink, Heat Dissipation, IC's, Fin Configuration & Thermocouples

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Original Article

1. INTRODUCTION

In modern and recent advances in the science & technology, especially in the electronics and computer application area, a lot of advancements have been taking place. Also with advent, few drawbacks are alsoseen in operations & application of electronic cooling in CPU. Recent advances using compact space for computers, heat dissipation from IC's has been a complex phenomenon. Hence, by using easy design &fabrication, experimental calculations are made by simulation. Software correlation has to be done for better design and performance of the heat sink.

Metal-foam heat sinks have received considerable attention Lee et al., [1] Antohe et al., [2]; Camidi and Mahajan, [3]; Hsieh et al., [7] Kim et al, [7] and this due to the interesting material properties. As stated earlier, these metal foams not only possess desirable properties of the bulk metal such as corrosion resistance, acceptance of coatings, and high electrical and thermal conductivity, but also qualities such as a low density, high strength-to-weight ratio, high porosity, and extremely large surface-area-to-volume ratio. Hsieh et al.[7] experimentally determined heat transfer correlations for 6 types of Al foam heat sinks (pore density: 10 - 40 ppi, porosity: 0.87 - 0.96) and found that increasing the porosity and the pore density results in a higher Nusselt number. It is similar to a processor cooling heat sink, with a fan mounted on top blowing air through the sink. of the air to reach the base surface resulting in a larger heat transfer rate.

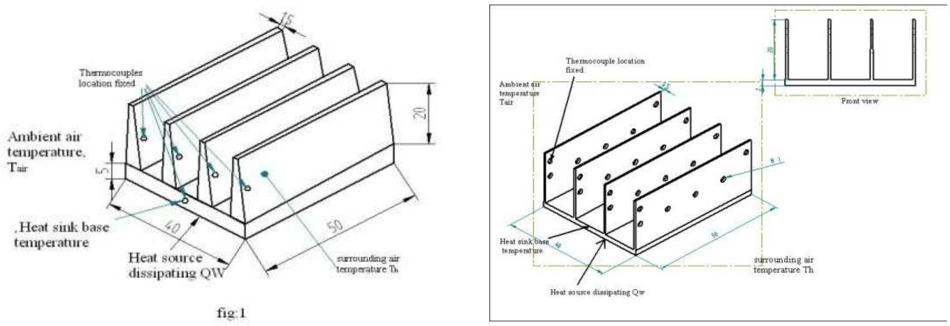
Dempsey et al. [8] experimentally compared the heat transfer performance of a stochastic cellular metal heat sink to a square-celled LCA. Bhattacharya and Mahajan[9] developed a new heat sink design, a finned metal foam heat exchanger. It consists of a number of parallel plate fins with metal foam joined in between. When used in natural convection mode, Bhattacharya and Mahajan [9] found that the finned metal foam heat sink provided an increase in heat transfer compared to an optimized plate fin heat sink. The 5 PPI foam results in an increase of the heat transfer coefficient ranging from 65% to 24% depending on the temperature difference between the base and the inlet air (10°C and 50°C respectively). In forced convection, the finned metal foam heat sinks also outperform the parallel plate heat sinks by a factor of 1.5 to 2. More dense foams provided less benefit due to increased flow resistance in both natural and forced convection. The results also indicated there is an optimal number of a fin depending on the applicationExperiments regarding the behavior of plate fin heat sinks were investigated by Duan and Muzychka [11]. They focused on the plate fin geometry and assumed one dimensional heat transfer in the radial direction. They tried different fin spacing and heights, in order to develop a heat transfer model to predict the behavior of the fin heat sinks based on each individual use. Heat sinks must be placed in the electronic applications in order to achieve an increased heat flux between the heated blocks El-Sayed et al.[6], Yazawa et al[9]., Fan et al., [6]. Heat sinks may vary significantly asfar as the design, material or the fins are concerned**.** However, they are chosen in order to suit the usage of each system. A lot of systems use a forced flow regime due to the fact that quite fast cooling of the electronic devices is needed.

Sultan, [4]; Banerjee et al [11]; Geisler, [11], but as the systems are improved, passive cooling is not the best option to be considered. The performance of electronic devices has been improving along with the rapid technology development. Cooling of electronic systems is consequently essential in controlling the component temperature and avoiding any hot spot. There are several methods to cool down the electronics components such as the pin-fin heat sink, confined jet impingement, heat pipe, and micro heat sink and so on. R Mohan and P Govindarajan, [13], springer, journal of mechanical science and technology, & KSME.

2. EXPERIMENTAL SETUP AND PROCEDURE

Firstly, a tapered fin of Aluminum & base plate material of copper of one specimen of dimensions 40mmx50mm x5mmwith, also second specimen with dimension of40x50x2.0mm is prepared. A small heater is attached at the base of copper plate. Both the materials have been machined carefully for the required dimensions. Silicon compound and Thermal adhesive are used to fix the Fins to the copper base plate. Aluminum tapered fins in 4 numbers are fixed to the copper plate. The fins of base thickness 2.5 mm & tip thickness 1.5 mm and 1 mm base and 05mm tip thickness of fins are respectively fixed. To regulate the heat, a centrifugal blower is fixed above the fins horizontally with flow rate of 90 CFM, with radius of fan diameter 90mm. Ten iron-constantan type thermocouples are used to measure the temperatures. The position of thermocouples on heat sink is at 10mm from the base of fin, each fin consist of two thermocouples, overall 8 thermocouples are there on fins. The copper base plate is fixed with 02 thermocouples at centre to measure the base plate temperature. Hence, a total of 10 thermocouples are fixed on the heat sink.

Heat is supplied to the heat sink heater with constant power of 20W, with steady state and even assumed that the change in maximum temperature was minimum than ±10°C for a time span of 4minutes. A voltmeter, wattmeter & temperature indicator were connected to measure the required parameter. Steady temperature of 50°C for heat sink is obtained with surrounding temperature as38°C. Both the specimen is as shown below in figure-1 and the dimensions used are given in table 1 &2.



(a) (b)

Figure 1: Heat Sink Specimen (a) Without Holes (b) With Holes

Table 1: Dimensions of the Heat Sink without Holes

Fin Length, L_f (mm)	**Fin Height H_f (mm)**	**Fin Width W_f mm**	**Fin Number N**	**Top Fin Thickness, t_{ft} (mm)**	**Fin –to-Fin Distance ξ (mm)**	**Base Thickness t_b (mm)**	**Base Fin Thickness t_{fb} (mm)**
50	20	40	04	1.5	7	5	2.5

Table 2: Dimensions of the Heat Sink with Holes

Fin Length, L_f (mm)	Fin Height H_f (mm)	Fin Width W_f mm
50	20	40
Fin Number N	Top Fin Thickness, t_{ft} (mm)	Fin –to- Fin distance ξ (mm)
04	0.5	15
Base thickness t_b (mm)	Base Fin Thickness t_{fb} (mm)	Holes on Sinks mm
2.0	1	4X4=16 holes of 2mm diameter

3 CFD ANALYSIS

CFD analysis of the experimental setup was conducted as per the conditions used in the experimentation. The heat sink model and the fluid domain were generated using CATIA V5 which was exported to the fluent component in the ANSYS solver. The inlet velocity was calculated from the fan flow rate and the temperature of the heat sink was kept at a steady 50°C. The analysis was performed for four models as given below.

- Heat sink without holes
- Heat sink with 8 holes
- Heat sink with 12 holes
- Heat sink with 16 holes

After the analysis, the three models with holes were compared to get the one with the best performance. The velocity profile obtained from CFD analysis of the specimen are as shown in Figure 3. Table 3 gives the comparison of experimental and analytical values obtained during this research work.

Table 3: Comparison of Experimental and Analytical Values obtained during this Research Work

Fin Configuration	Mass Flow Rate (kg/s)		Heat Transfer co-Efficient (W/m^{2}K)	
	Experimental	Analytical	Experimental	Analytical
Without Holes	0.0495	0.0492	22.7698	22.0867
With 8 Holes	0.0495	0.0493	22.7702	21.8594
With 12 Holes	**0.0495**	**0.0926**	**22.7745**	**22.3190**
With 16 Holes	0.0495	0.04917	22.7812	22.6421

- Graphical comparison of Experimental and analytical values of Heat transfer coefficient in heat sink

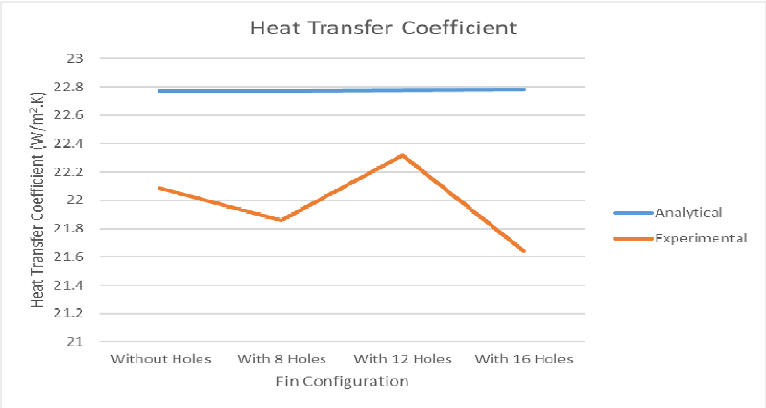


Figure 2

- Graphical comparison of Experimental and analytical values of Mass flow rate in heat sink

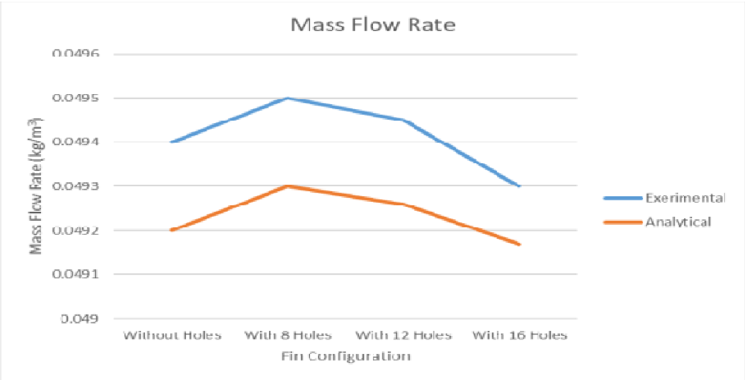
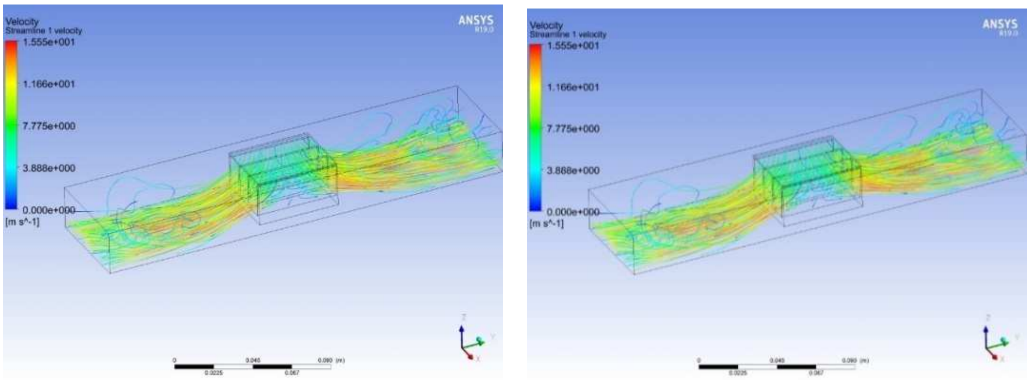
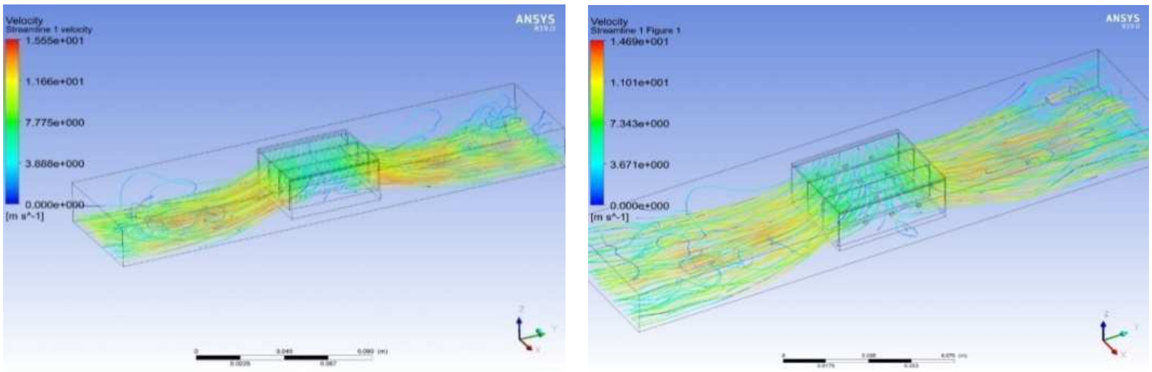


Figure 3



(a) **(b)**



(c) **(d)**

Figure 4: Velocity Profile of the Heat Sink (a) without Holes (b) with 8 Holes (c) with 12 Holes (d) with 16 Holes

4. CONCLUSIONS

The main focus of this research work is to compare the heat transfer between heat sinks of different configurations. This was achieved by comparing four different configurations i. e., Heat sinks without holes, with 8 holes, with 12 holes and with 16 holes. The heat transfer co-efficient obtained through experimentation and CFD analysis indicated that the theoretical model selected for analysis was similar to the experimental model, and the values are in close agreement with each other with a very small difference between 1-1.5%.

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